Rare and Exotic Processes at CDF

Search for Anomalous $\gamma\gamma$+X
Search for Anomalous $\gamma b \not{E}_T$
Search for Fermiophobic Higgs

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for the CDF Collaboration

Signature-Based Searches

First two of three results shown here are SBS

The Idea

- Chose a signature
- Define a nominal selection, with variations
- Compute SM backgrounds
- Report event yields and kinematics
- Investigate discrepancies

The Why

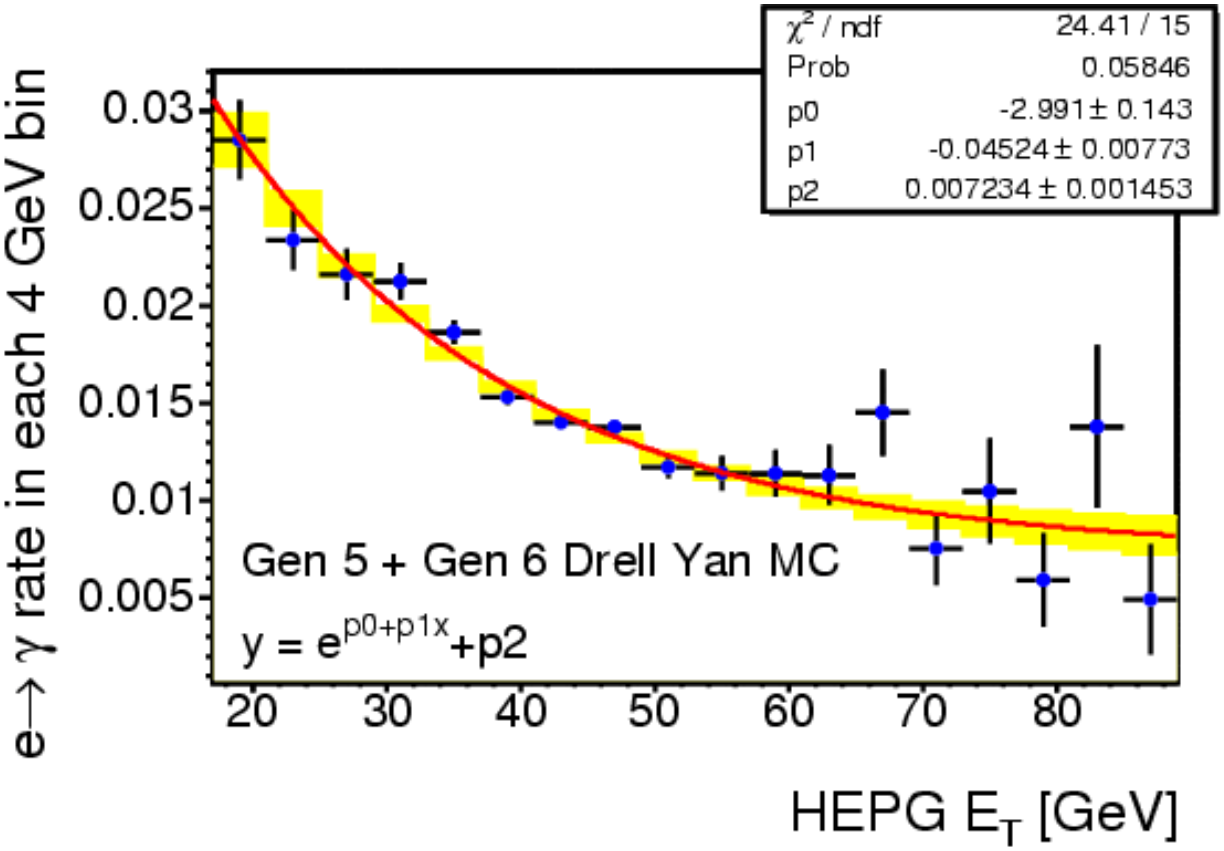
- There are many models, very few are obviously more likely than others
- Model limits usually do not provide critical insight
- Save time – cover more signatures
- Experimental results are experimental

Search for Anomalous $\gamma\gamma$+X

Search for Anomalous γγe/μ

Event Selection

- ♦ 1 fb^{-1}
- ♦ Two photons
  E_T>13 GeV, |η|<1.1
- ♦ Electron
  - central or forward
  - E_T>20GeV
- ♦ Muon
  - |η|<1.0
  - P_T>20 GeV

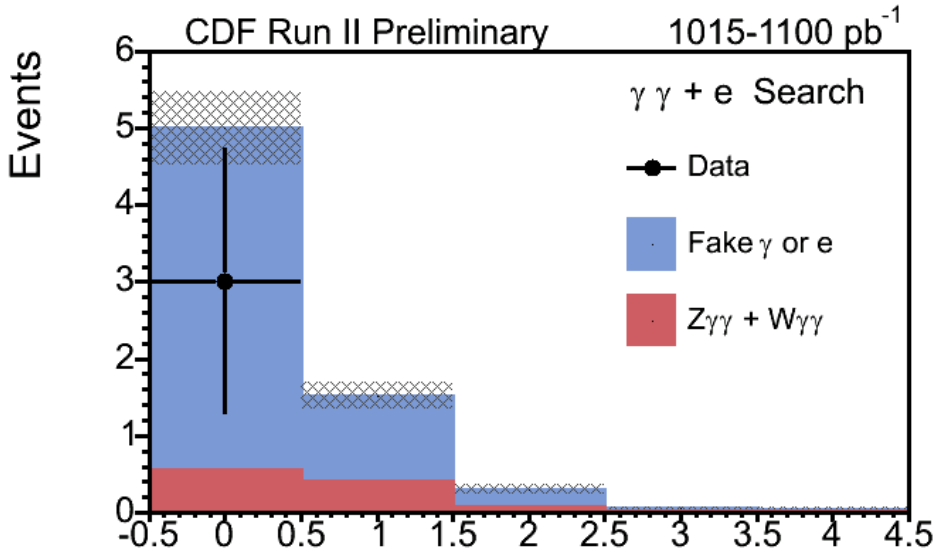


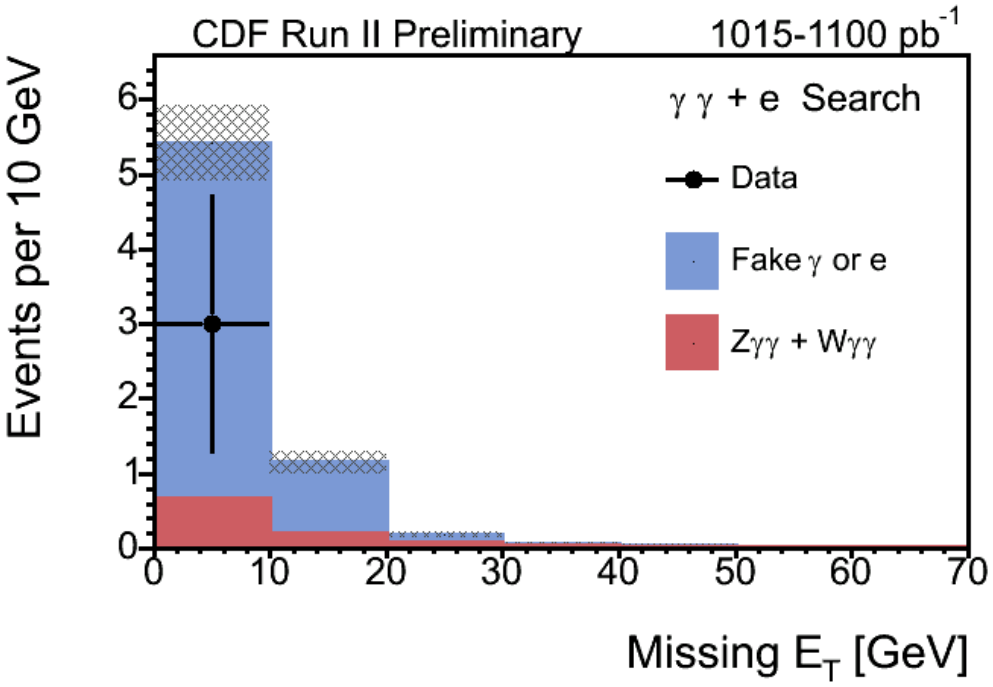
Backgrounds

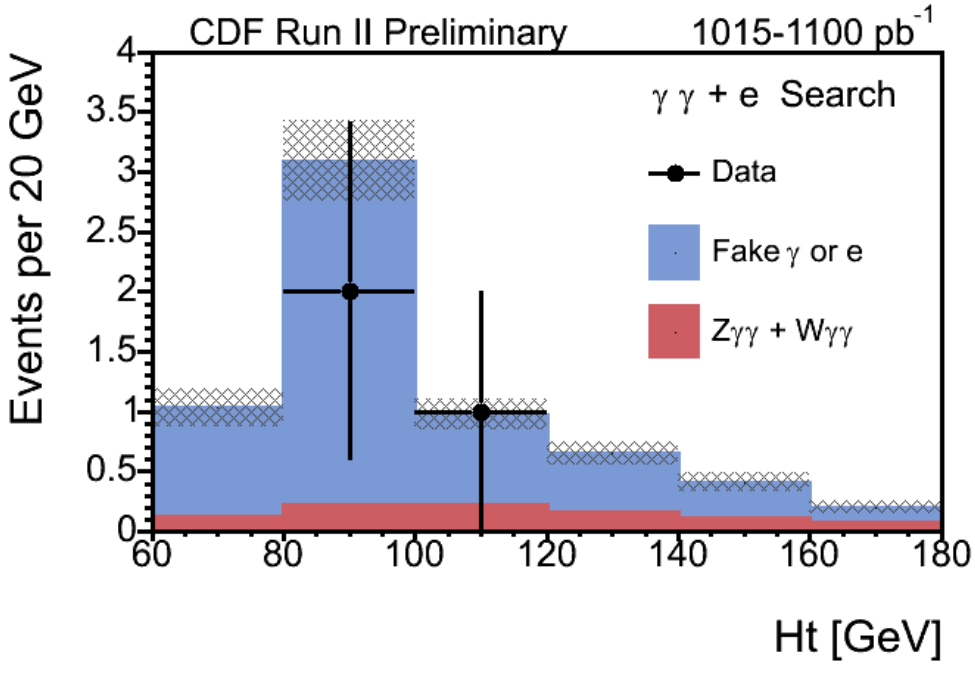
- ♦ W/Zγγ: MadGraph+Pythia, k-factor
- ♦ W/Zγ, with electron faking photon
- ♦ Fake leptons and jets faking photons (small)

γγe/μ Kinematics

Before applying Phoenix rejection		
Source	electron	muon
$Z\gamma\gamma$	$0.904 \pm 0.023 \pm 0.083$	$0.552 \pm 0.017 \pm 0.050$
$W\gamma\gamma$	$0.170 \pm 0.012 \pm 0.016$	$0.086 \pm 0.008 \pm 0.008$
Fake $l+\gamma\gamma$	$0.131 \pm 0.004 \pm 0.053$	$0.004 \pm 0.003 \pm 0.002$
$l\gamma + \text{jet} \rightarrow \gamma$	$0.475 \pm 0.025 \pm 0.312$	$0.133 \pm 0.013 \pm 0.090$
$l\gamma + e \rightarrow \gamma$	$5.140 \pm 0.340 \pm 0.584$	$0.017 \pm 0.017 \pm 0.002$
Total	6.82 ± 0.75	0.79 ± 0.11
Data	3	0



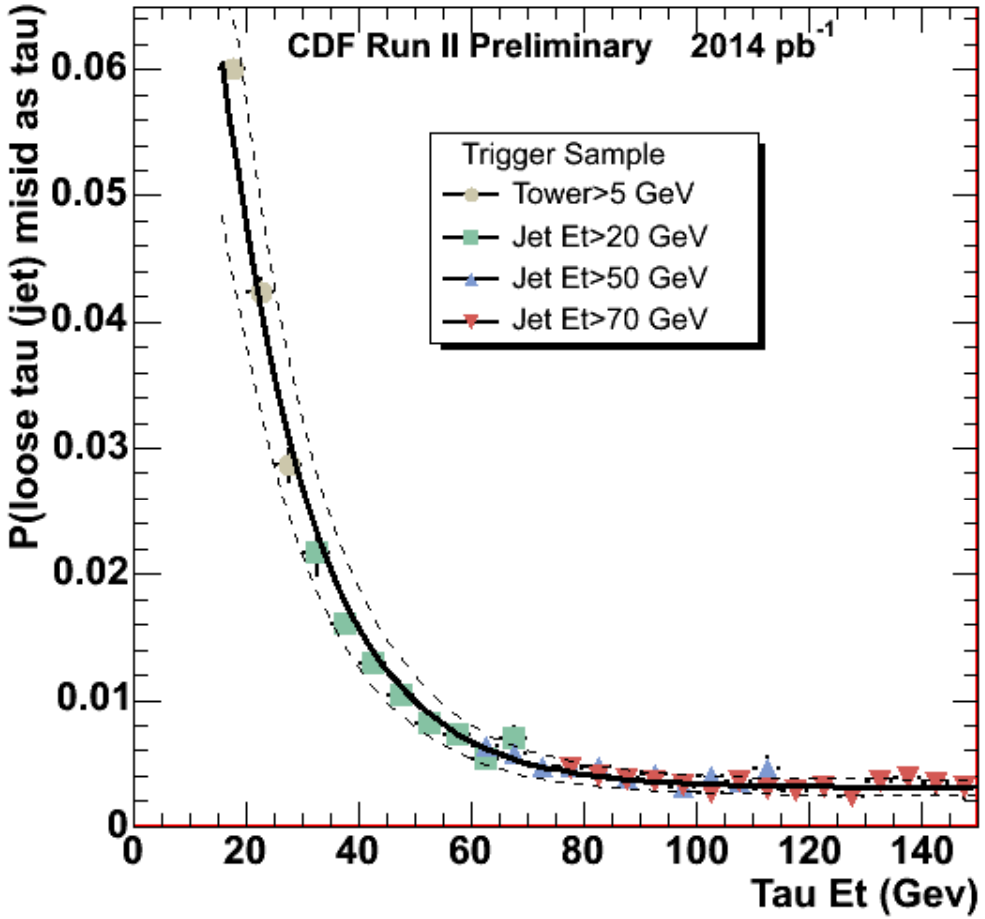




Search for Anomalous γγτ

Event Selection

- ♦ 2 fb^{-1}
- ♦ Two photons
  E_T>13 GeV, |η|<1.1
- ♦ Hadronic τ
  - narrow calorimeter cluster
  - E_T >15 GeV
  - 1 or 3 tracks
  - isolation cone



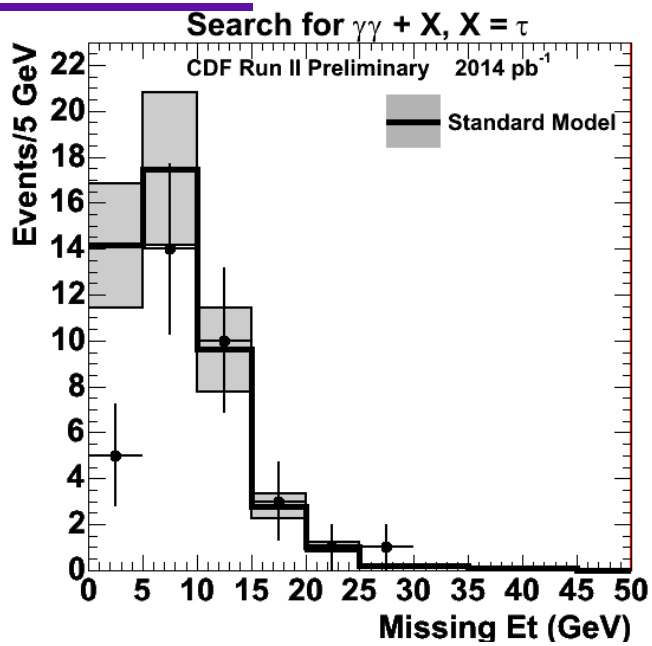
Backgrounds

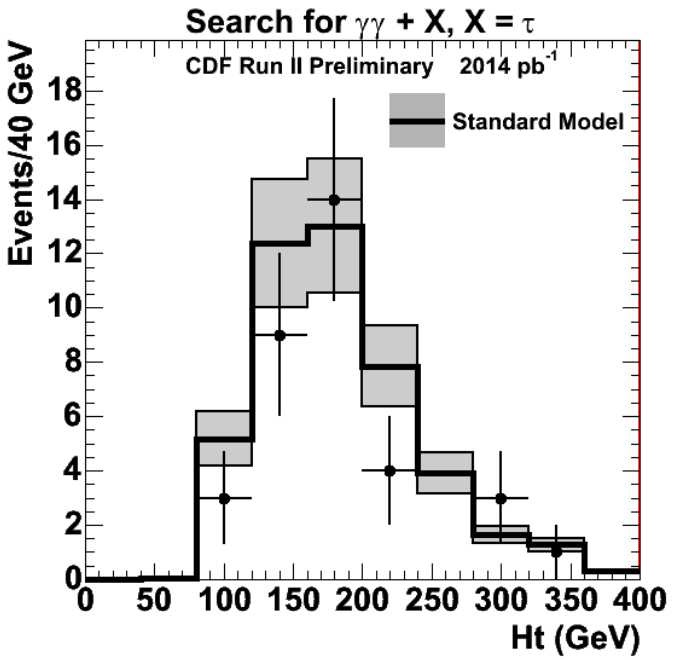
- ♦ W/Zγ,W/Zγγ: MadGraph+Pythia, k-factor
- ♦ Fake τ's
  - define a loose tau, and measure fake rate: loose → tight

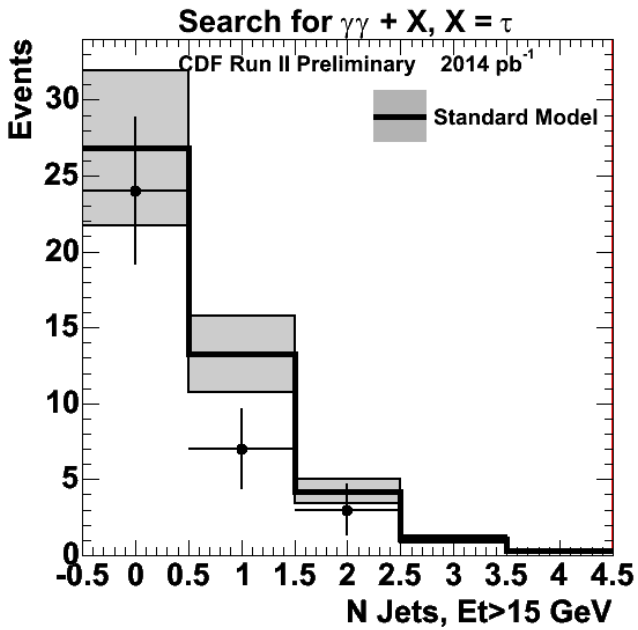
γγτ Kinematics

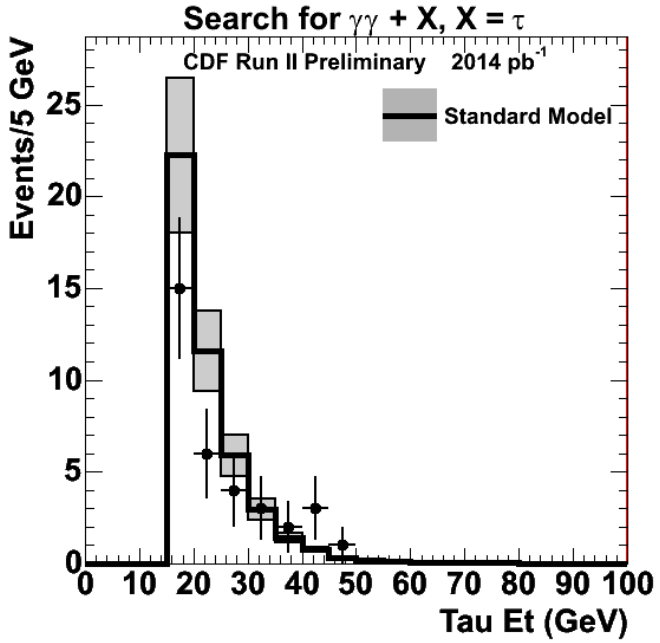
Results for γγτ

fake τ	44±10
W/Z+τ	2.2±1.0
Total	46±10
Obs	40









Search for Diphoton and MET

Data Sample

♦ 2 fb^{-1}

♦ Two photons,

$|\eta|<1.1$, $E_T>13GeV$

Backgrounds

♦ Non-collision

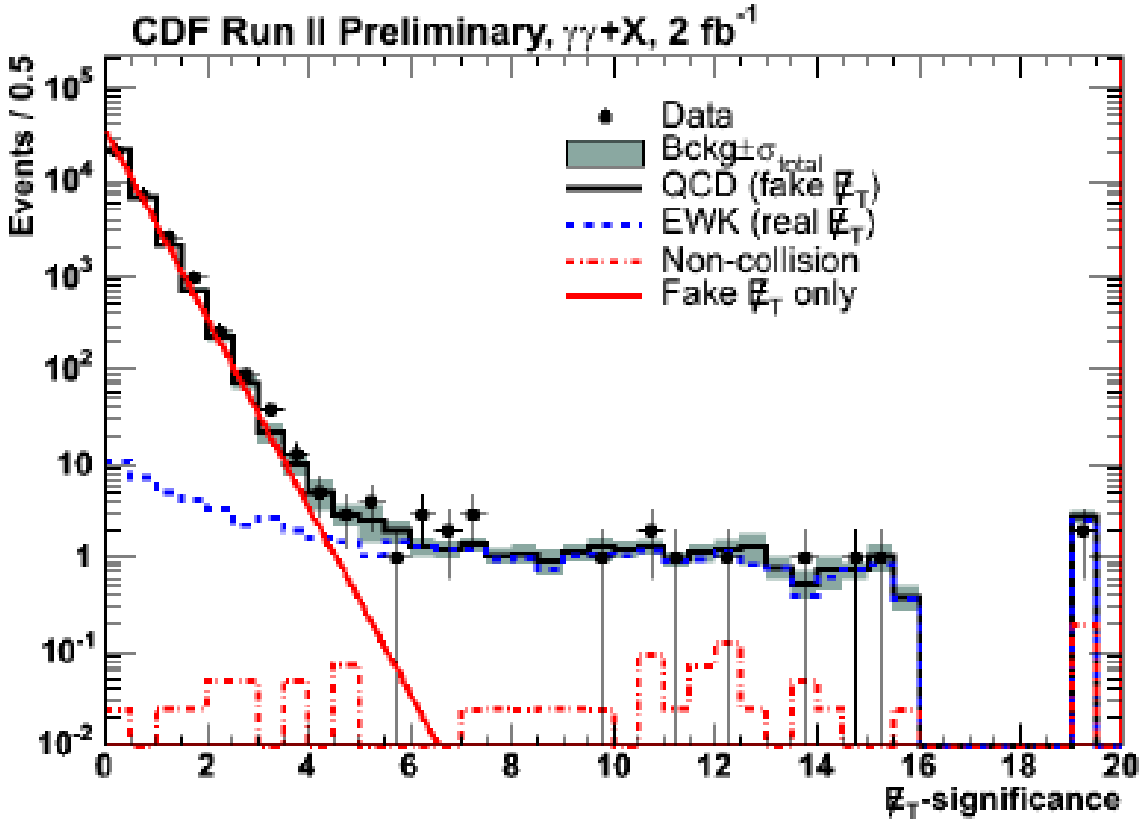
→topology, EM timing

♦ Wγ, electron

faking photon →MC, normalized to data

♦ QCD with fake MET

→MET Model of jet resolution



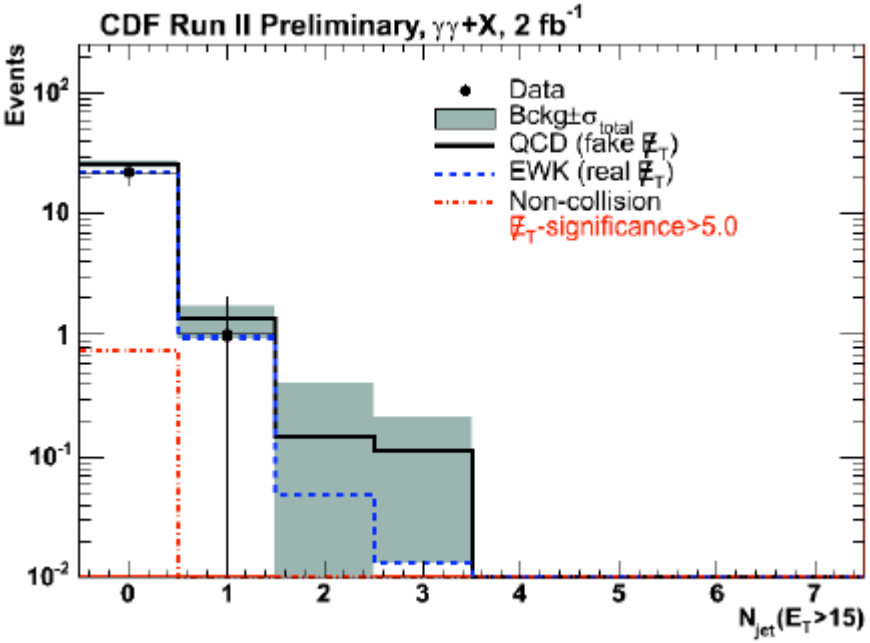
MET Model: use the topology of each event to estimate the MET it could produce due to energy resolution, and therefore how significant the observed MET is

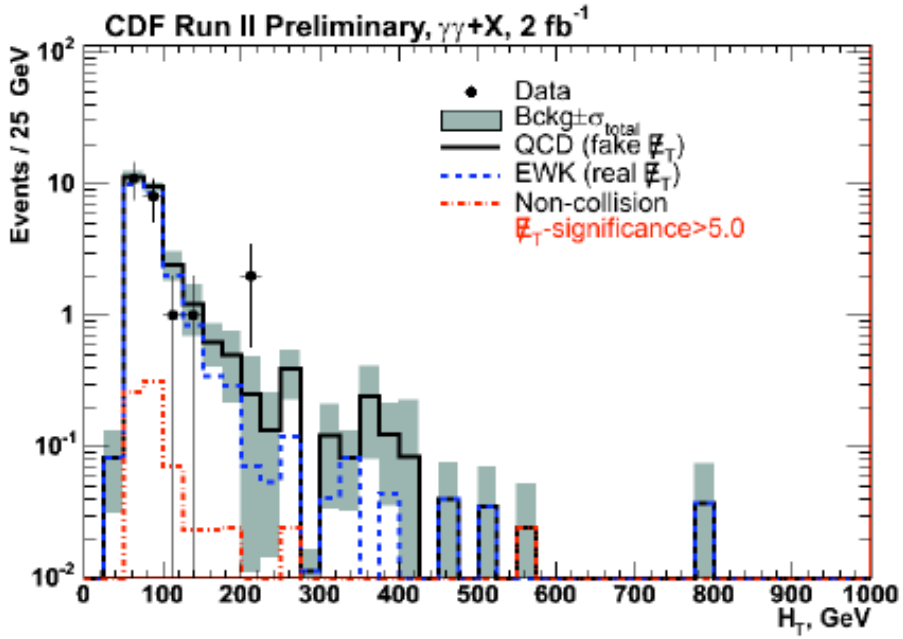
Search for Diphoton and MET

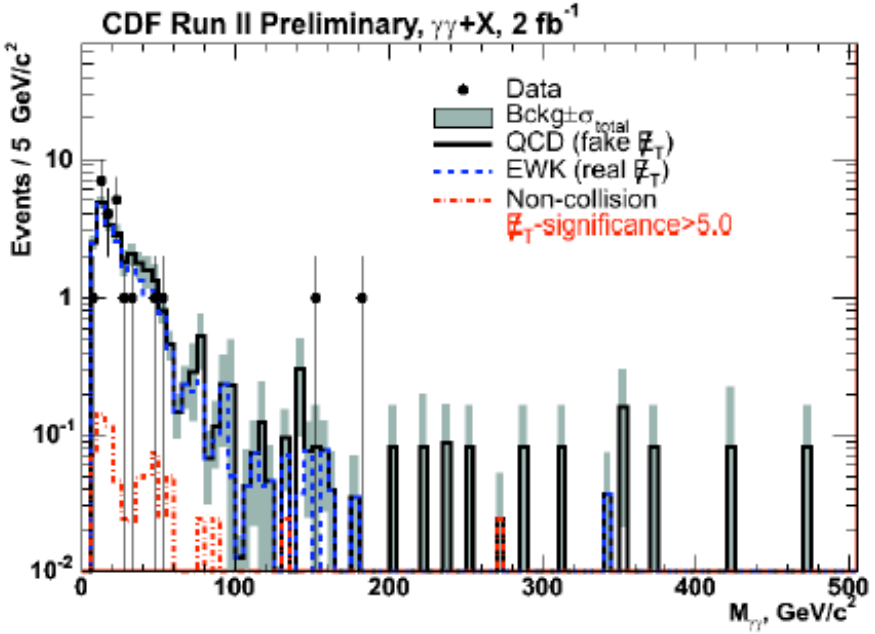
	MetSig >3	MetSig>5
bkg	67.9±7.5	27.3±2.3
data	82	23

Wγ MetSig selection efficiency:

84% 67%



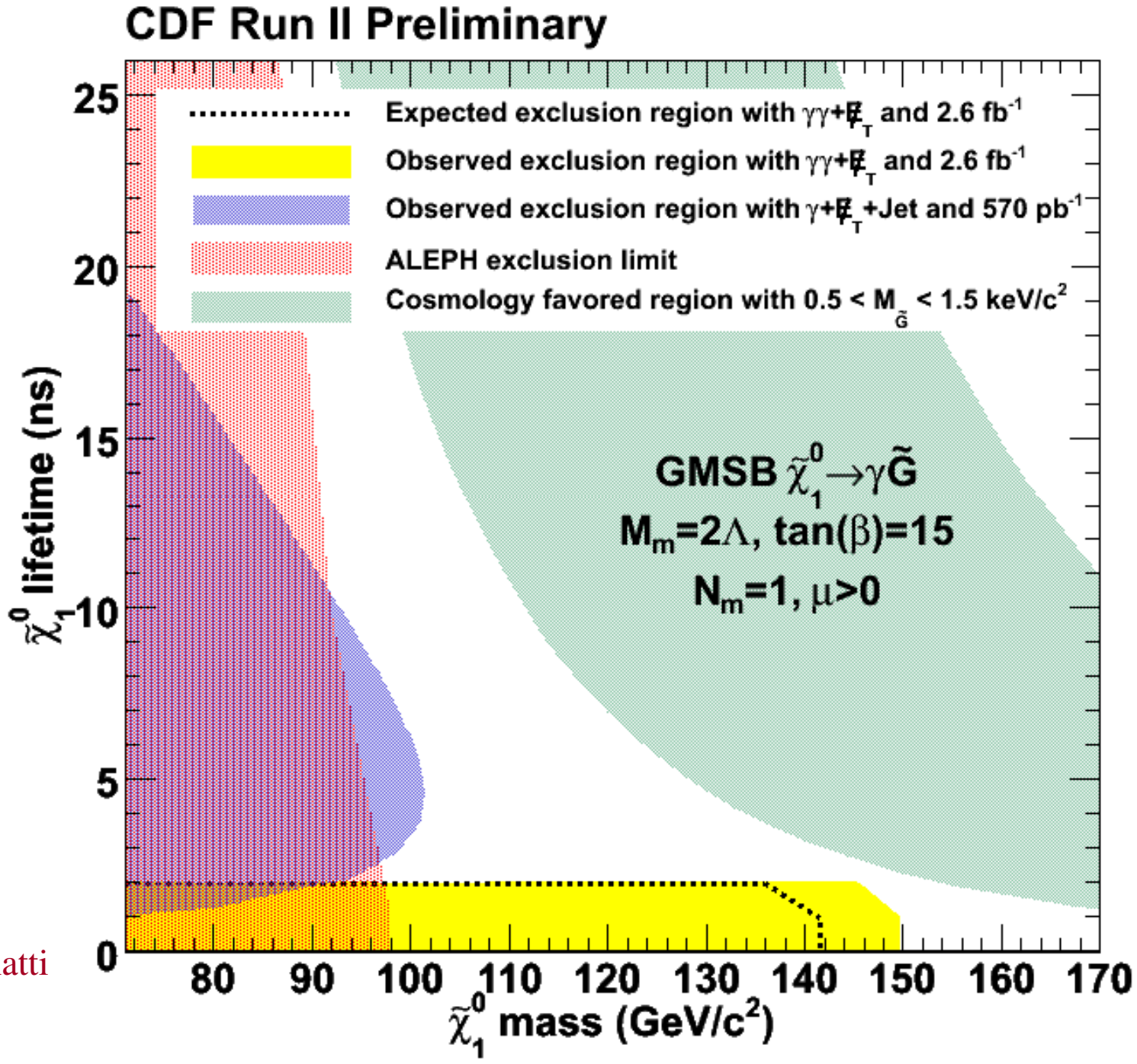




GMSB Limits

Re-optimize
H_T
MetSig
$\Delta\varphi$ ($\gamma\gamma$)

With no lifetime,
$M(\chi_1)>149$ GeV



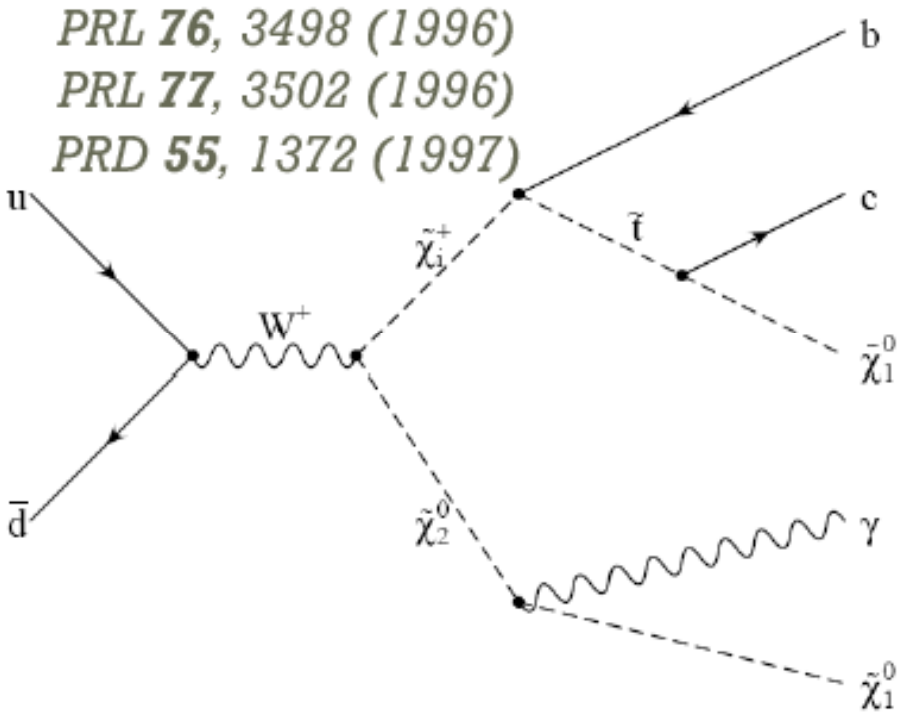
B. C. Allanach et al, Eur. Phys. J C25 113 (2002)
E. Blatz et al., J. High Energy Phys. 0305, 067 (2003)

See also talk by Anwar Bhatti

Search for Anomalous $\gamma b \not{E}_T$

Introduction

- Signature-based
- Real γbMET is rare,
  < 3% of sample
- Most from mismeasured E_T
- Several models exist



Data Sample

Dataset
- ♦ 2 fb^{-1} of data
- ♦ Trigger: inclusive photon

Base Event Selection
- ♦ γ E_T>25 GeV, |η|<1.1
- ♦ 1 jet with corr E_T>15 GeV
- ♦ jet is tagged by a secondary vertex

Final Event Selection
- ♦ second jet
- ♦ Δϕ(jet-MET) > 0.3
- ♦ ΔR>0.4 for all combinations of photons and jets
- ♦ MET > 25 GeV

Backgrounds

1) Fake photons
2) Real photon, fake b-tag
3) Real photon, real b
4) Real photon, real charm

Background 1,2

Method

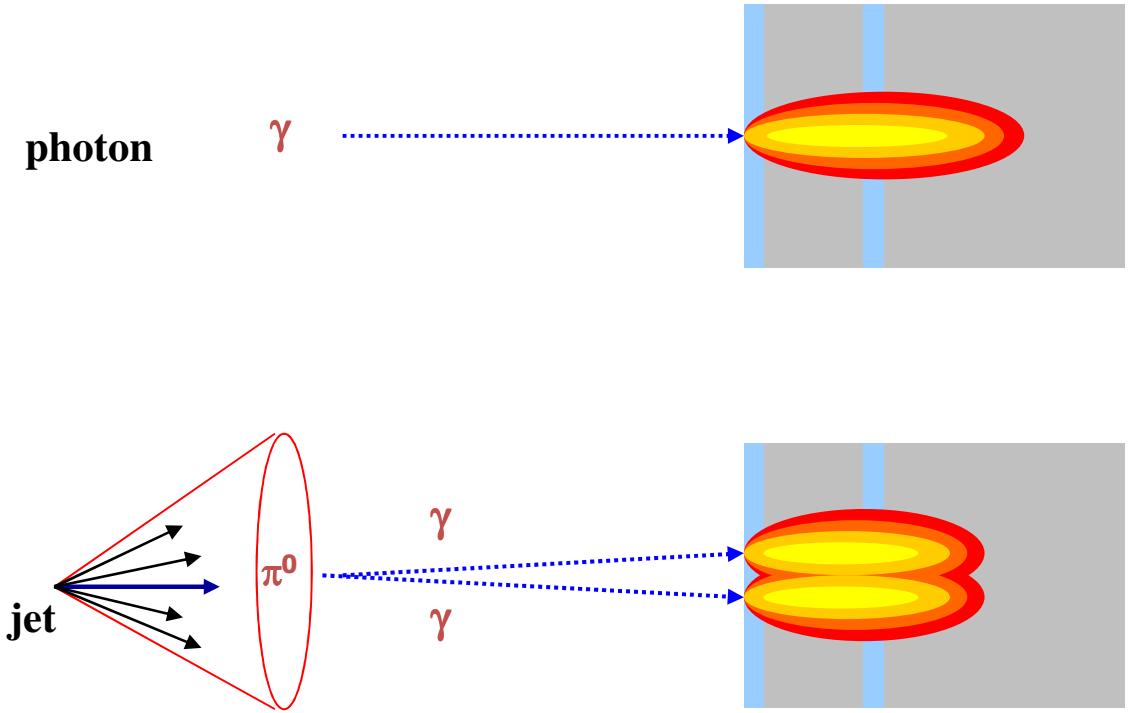
- Exploit two photons in a π^0

CES

- E_T<35 GeV
- CES=Shower-Max
- Shower shape
  in shower max detector

CPR

- E_T>35 GeV
- CPR=central pre-radiator
- Conversion rate in CPR



- BG 1 (fake γ) apply reverse CES/CPR method to final selection
- BG 2 (real γ, fake b) apply CES/CPR and
  a jet mis-b-tag probability, to the sample before b-tagging

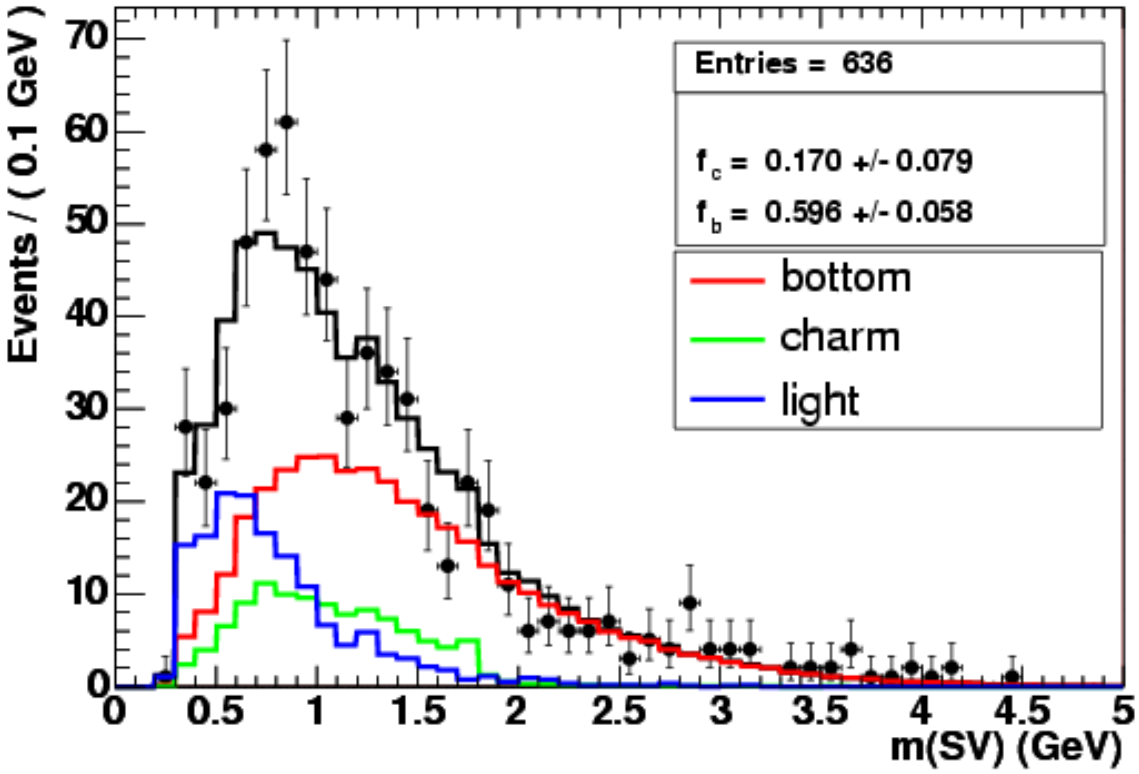
Heavy Flavor Fit

HF MC Sample

- γb γc
- MadGraph+Pythia
- CKKW matching

HF fractions

- Fit secondary vertex mass
- b,c from MadGraph
- ucd from Pythia



Background 3,4 – γb,γc

Normalization for γb

- In base γb sample, find b fraction
- Includes real and fake photons – which have different b fractions
- Adjust b fraction based on b fractions in fake photon sample, weighted by CES/CPR result
- Apply MC efficiency for signal region cuts: E_T,Δϕ, 2nd jet (0.0123±0.0025)

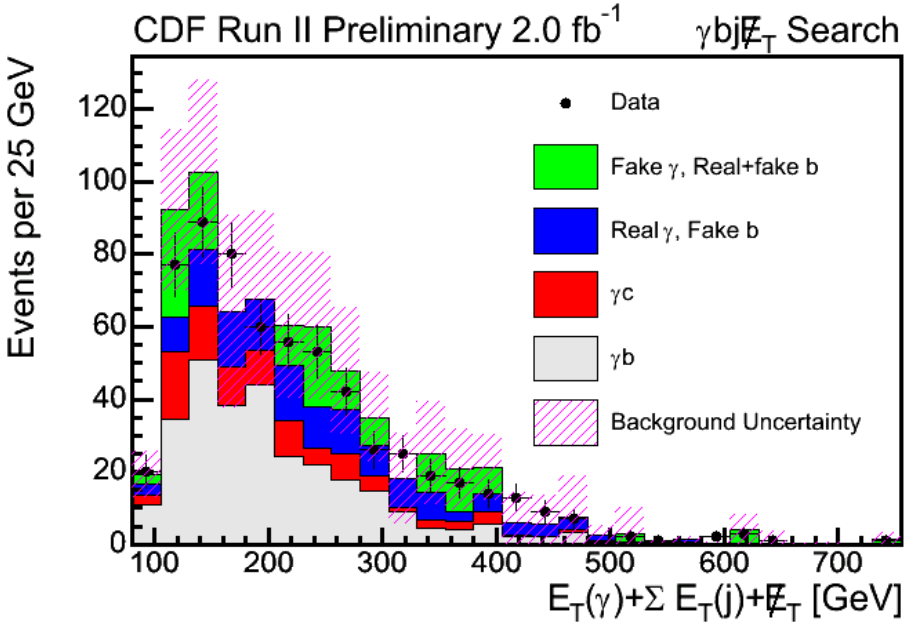
Normalization for γc

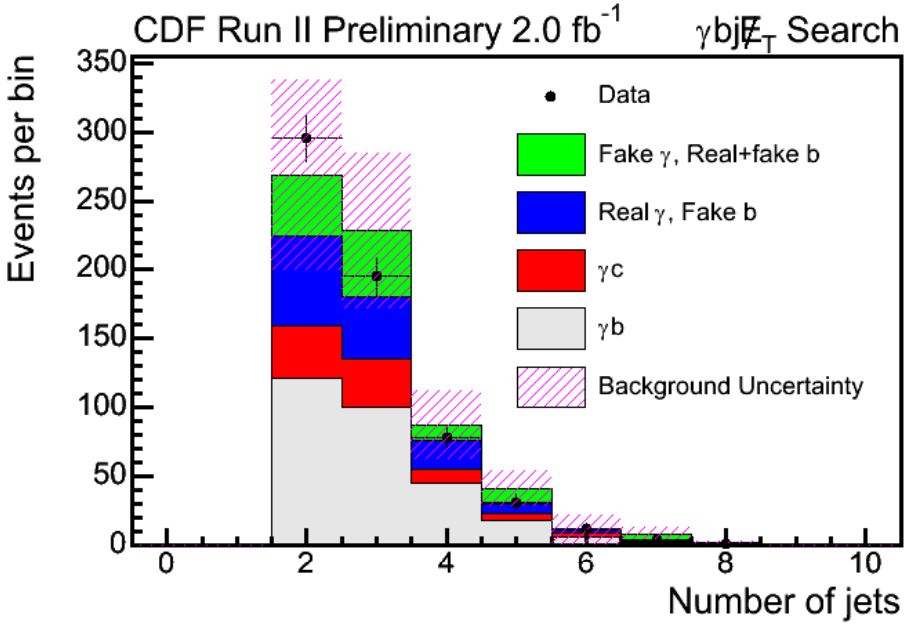
- Do not have a reliable enough MC efficiency to apply the b method to c
- Simply run the fit in the signal region (therefore insensitive to a charm signal)

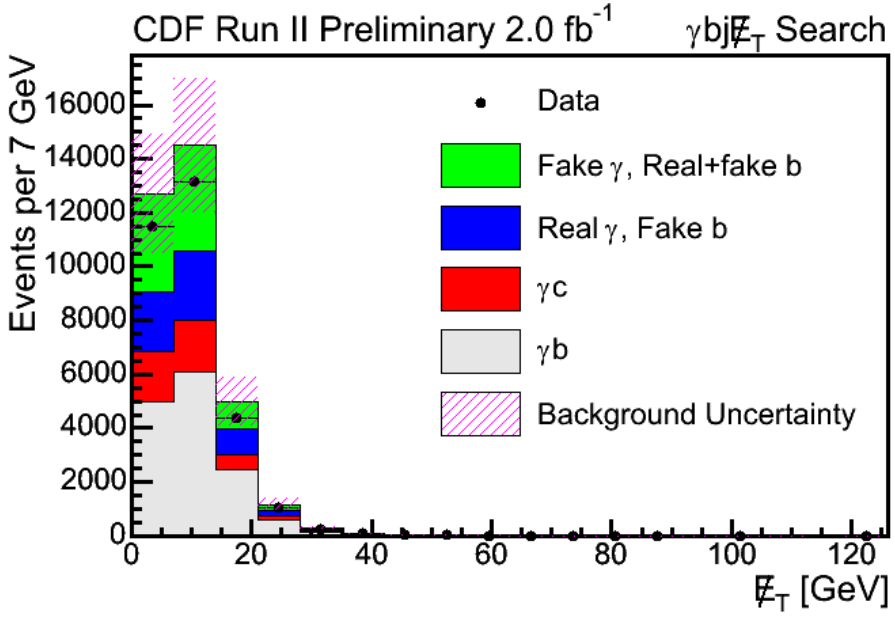
Results for γbjMET

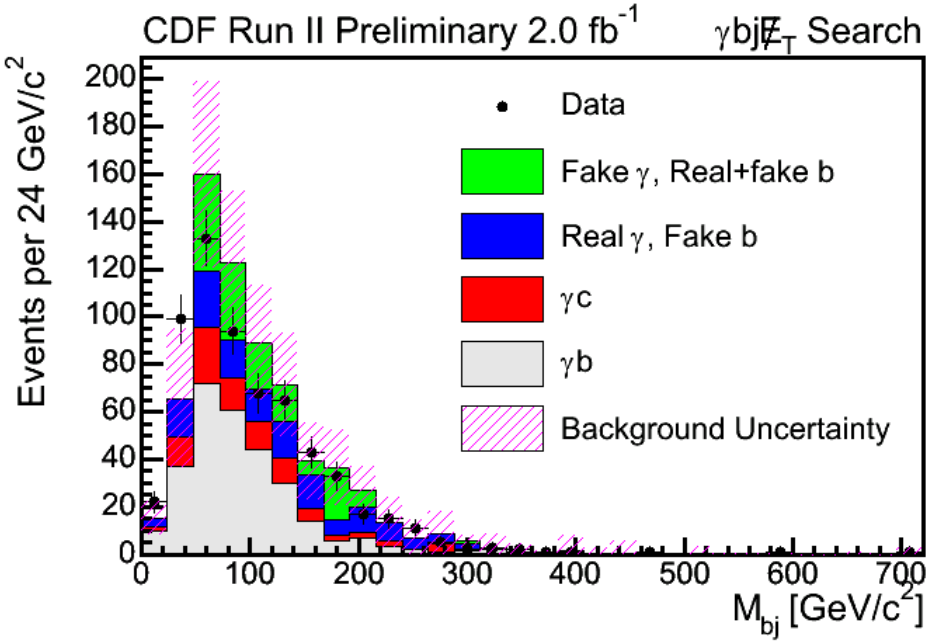
fake γ	115±49±54
γ, fake b	141±6±30
γb	341±18±91
γc	9±52±14
Total	607±74±86
Obs	617

Kinematics


CDF Run II Preliminary 2.0 fb^{-1}
γbj$\not\!\!E_T$ Search
Data
Fake γ, Real+fake b
Real γ, Fake b
γc
γb
Background Uncertainty
Events per 25 GeV
$E_T(\gamma)+\Sigma E_T(j)+\not\!\!E_T$ [GeV]


CDF Run II Preliminary 2.0 fb^{-1}
γbj$\not\!\!E_T$ Search
Data
Fake γ, Real+fake b
Real γ, Fake b
γc
γb
Background Uncertainty
Events per bin
Number of jets


CDF Run II Preliminary 2.0 fb^{-1}
γbj$\not\!\!E_T$ Search
Data
Fake γ, Real+fake b
Real γ, Fake b
γc
γb
Background Uncertainty
Events per 7 GeV
$\not\!\!E_T$ [GeV]


CDF Run II Preliminary 2.0 fb^{-1}
γbj$\not\!\!E_T$ Search
Data
Fake γ, Real+fake b
Real γ, Fake b
γc
γb
Background Uncertainty
Events per 24 GeV/c^2
M_{bj} [GeV/c^2]

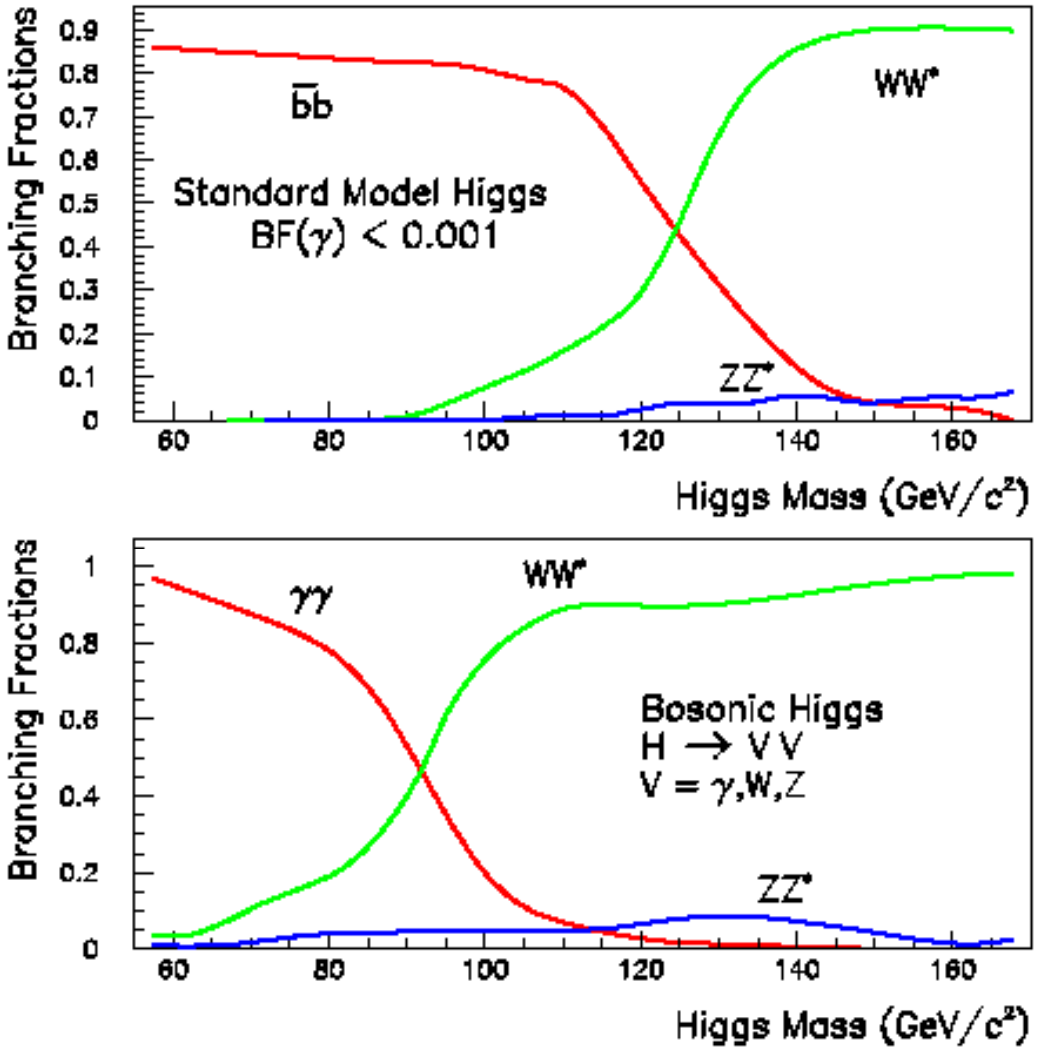
Search for Fermiophobic Higgs

Fermiophobic Higgs

♦ Available in many SM extensions with 2 Higgs doublets

♦ Mild fine tuning can turn off fermion couplings, boson couplings unaffected

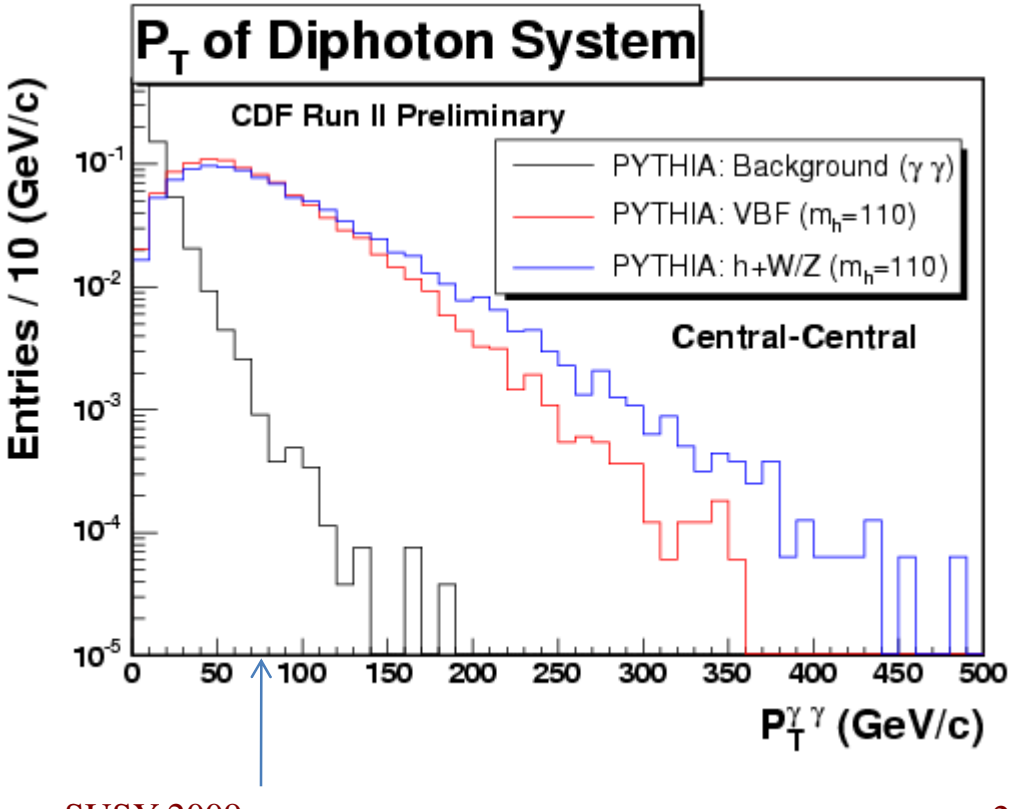
♦ Cross section relative to SM ×0.5, BR ×100

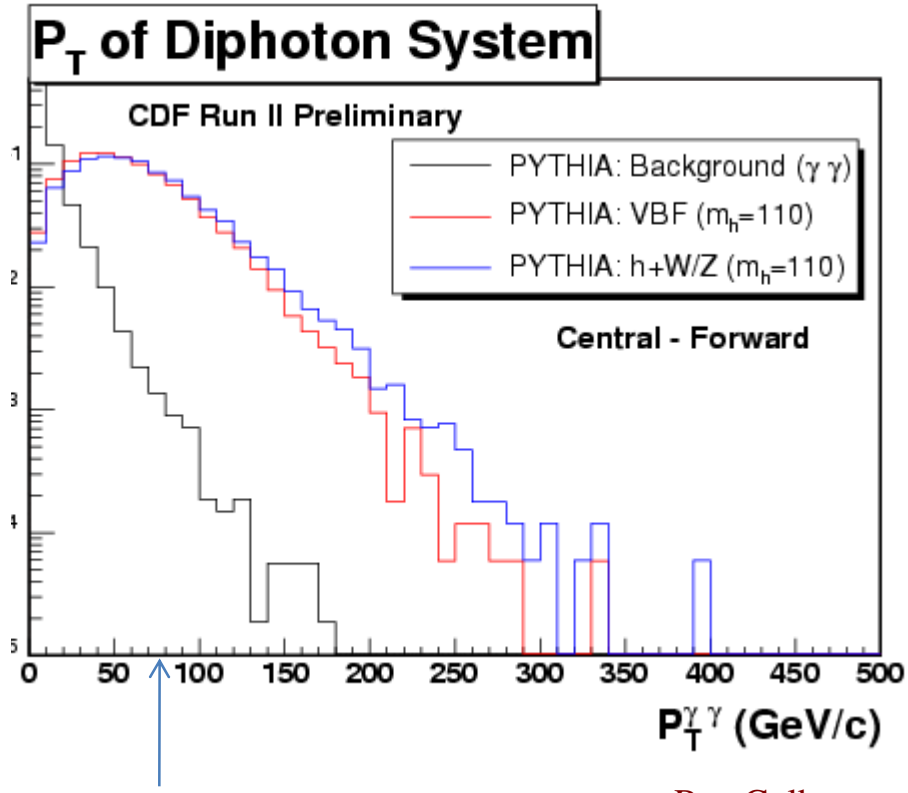


1)~~Gluon Fusion~~ 2)Associated Production 3)Vector Boson Fusion

Optimization

- Look for evidence of associated W's and Z's –
  MET, isolated tracks, 2 jets or…
- Simple $P_T(\gamma\gamma)$ cut - clear winner: $P_T(\gamma\gamma) > 75$ GeV
- Reject 99.7% of background, only 30% of signal (total eff ~5%)
- Confirm with variations of background predictions
- P_T spectrum stable LO to NLO





Data Fits

Dataset

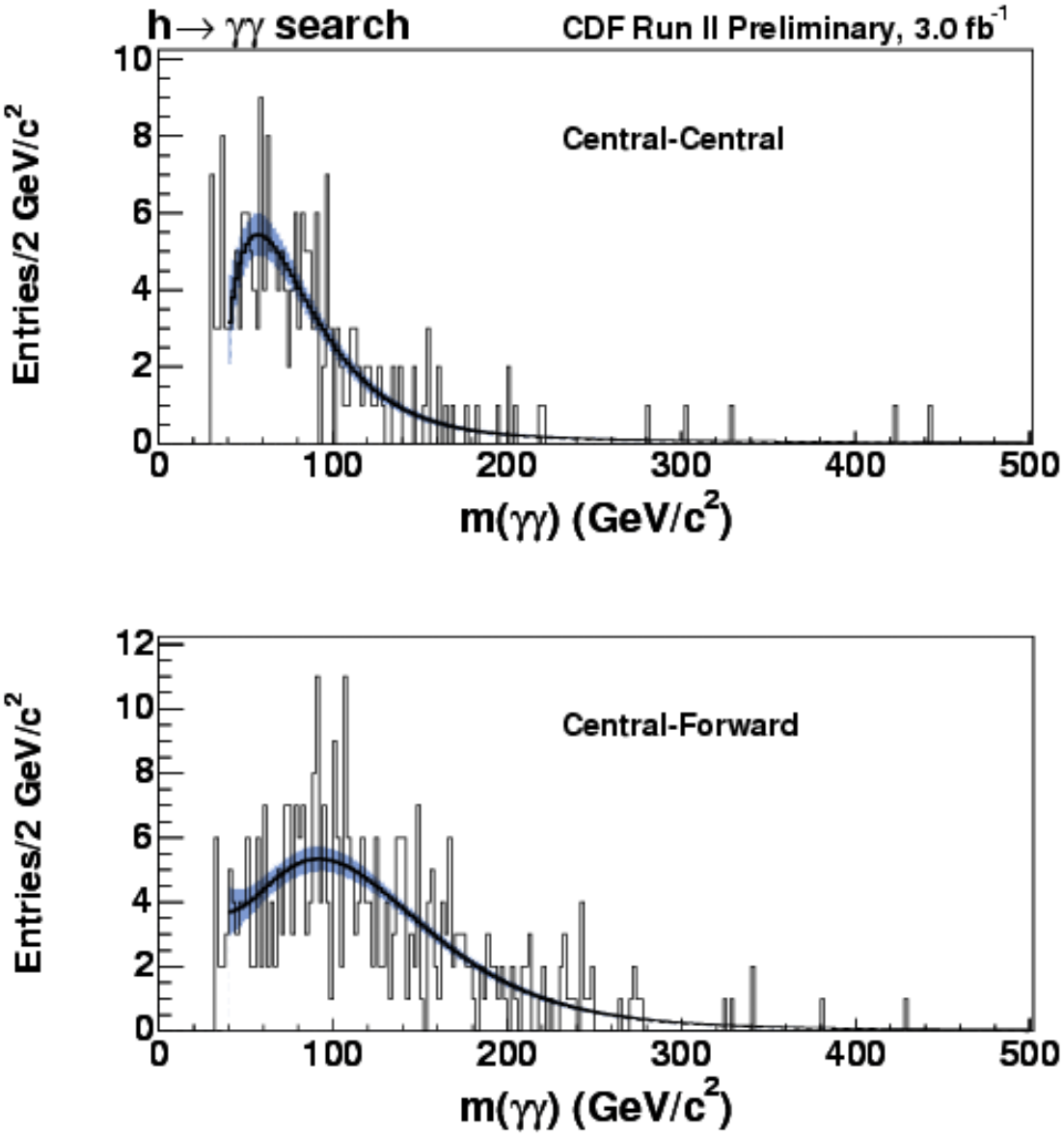
- 3.0 fb^{-1}
- Diphoton plus single photon triggers
- Two isolated, well-identified photons, Et>15GeV

Central -Central($|\eta|<1.1$) or Central-Forward ($2.2<|\eta|<2.8$)

- $P_T(\gamma\gamma) > 75$ GeV

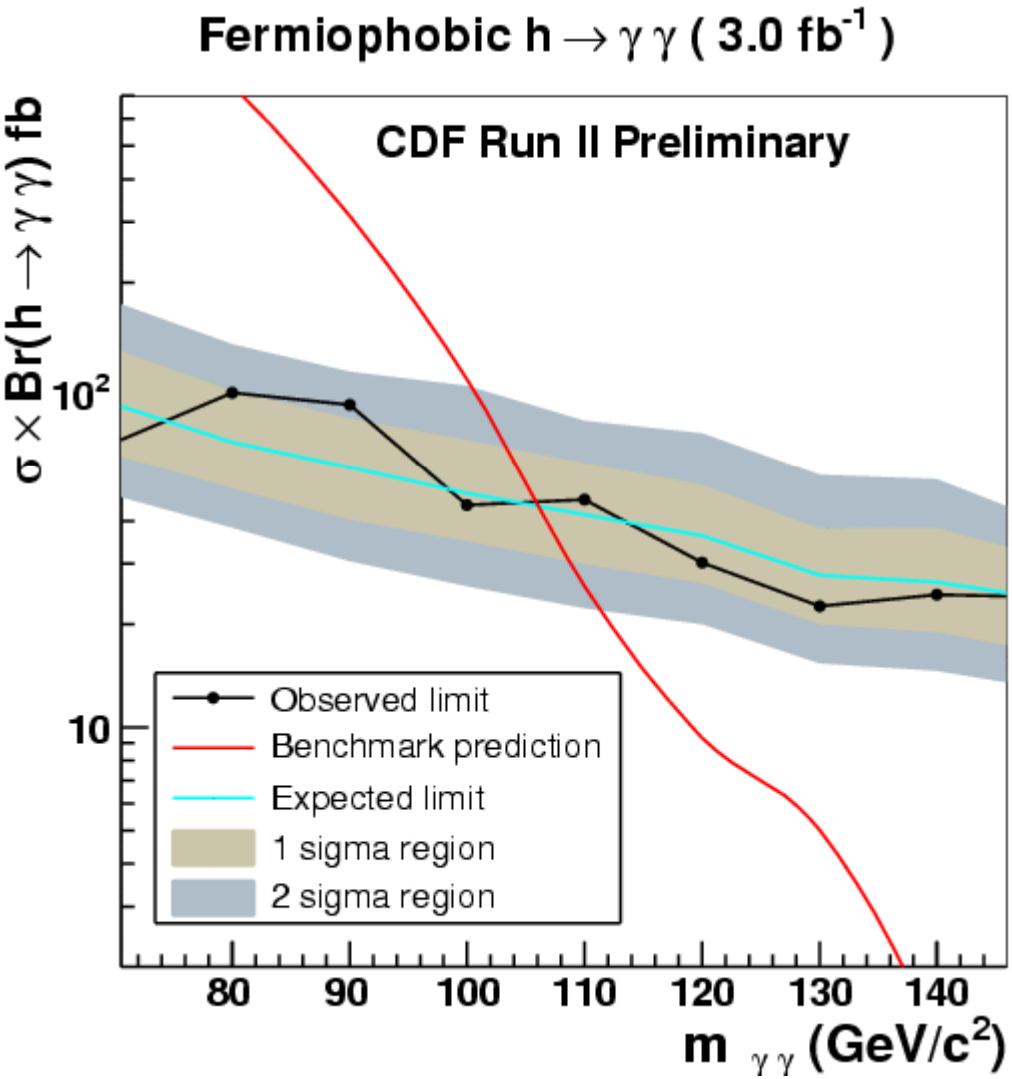
Fit

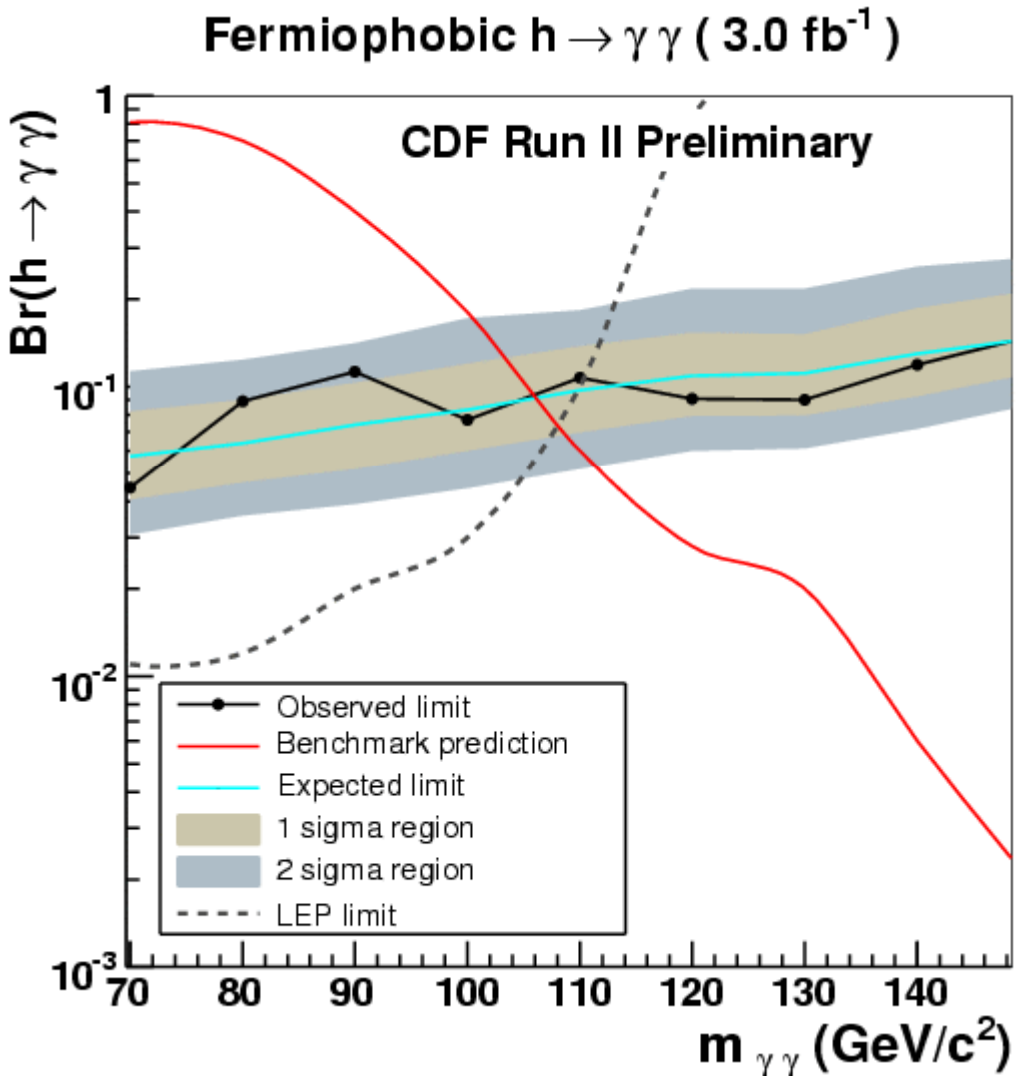
- Binned likelihood
- MC signal line shape
- Exponential eq. for background lineshape
- background shape → 20% σ



Fermiophobic Higgs

Final mass limit $m(h_f) > 106$GeV submitted - arXiv:0905.0413





(LEP 109.7, D0 preliminary 102.5)

Searched $\gamma\gamma$+X
GMSB limit χ_1>149 GeV

Searched $\gamma b \not{E}_T$

Fermiophobic Higgs > 106 GeV

Thank you..

Limit Projections

Project
$\gamma\gamma$+ME_T
and
γj+ME_T +EM time
analyses